

CLAIMS

What is claimed is:

1. A method comprising:

5 determining a spacing for each of a plurality of edges comprising one or more features in a photolithographic design, said plurality of edges having at least a partially predictable layout;

generating a bridge structure for the plurality of edges based on the spacings and the predictable layout, each bridge of the bridge structure to connect one of the plurality of edges to an edge of a neighboring feature; and

10 providing the features and the bridge structure for a phase assignment, said phase assignment to assign features at opposite ends of each of said bridges to opposite phases.

15 2. The method of claim 1 wherein generating the bridge structure comprises:

categorizing at least one pair of the plurality of edges as near edges; and
filling a space between each pair of near edges with a bridge.

3. The method of claim 1 wherein generating the bridge structure comprises:

20 categorizing at least one pair of the plurality of edges as medium edges;
inserting a sub-resolution assist feature (SRAF) between each pair of medium edges; and

filling a space between each medium edge and its corresponding SRAF with a bridge.

4. The method of claim 1 wherein generating the bridge structure comprises:

5 categorizing a set of the plurality of edges as far edges;
inserting a sub-resolution assist feature (SRAF) for each far edge; and
filling a space extending from one or more of the set of far edges with a bridge.

5. The method of claim 4 wherein filling the space comprises:

10 identifying any of the SRAFs that are within a minimum separation distance from
another feature;

15 increasing a separation distance to at least the minimum separation distance for
any identified SRAFs by resizing, merging, and/or deleting the identified SRAFs as
needed;

20 adding a bridge between any far edge and its corresponding SRAF where the
corresponding SRAF still exists or was merged; and

 adding a bridge between any pair of far edges for which both corresponding
SRAFs were deleted.

20 6. The method of claim 1 wherein generating the bridge structure comprises:

 introducing a sub-resolution assist feature (SRAF) for one of the plurality of
edges having a particular spacing; and

connecting one of the bridges of the bridge structure between the edge having the particular spacing and the SRAF.

7. The method of claim 6 wherein generating the bridge structure further comprises:

5 repeating the introducing and connecting for a plurality of additional edges having the particular spacing.

8. The method of claim 6 wherein the particular spacing is a first particular spacing, and wherein generating the bridge structure further comprises:

10 repeating the introducing and connecting for a plurality of additional edges having a second particular spacing.

9. The method of claim 1 wherein generating the bridge structure comprises:

15 introducing a plurality of sub-resolution assist features (SRAFs), wherein particular ones of the neighboring features comprise the plurality of SRAFs.

10. The method of claim 9 wherein providing the features and the bridge structure comprises:

20 merging the plurality of features and the plurality of SRAFs to a target layer for the phase assignment; and

merging the bridge structure to a bridge layer for the phase assignment.

11. The method of claim 1 wherein the photolithographic design comprises a mask design for a contact layer of an integrated circuit design.

12. The method of claim 1 wherein the one or more features comprise one of a square feature, an array of square features, a rectangular feature, and an array of rectangular features.

13. The method of claim 1 wherein the bridge structure comprises a temporary design artifact representing an additional layer in an integrated circuit design.

14. The method of claim 1 wherein determining the spacing comprises:

measuring each of the spacings as a projection perpendicular from each of the plurality of edges to a neighboring edge or to a maximum projection distance.

15. The method of claim 1 wherein the one or more features comprise staggered sets of features having a shorter spacing between neighboring features in neighboring staggered sets than between neighboring features within each set, and wherein generating the bridge structure comprises:

merging each said staggered set into a strip feature; and

filling the bridges between neighboring strip features.

16. The method of claim 1 wherein the spacing for each of the plurality of edges comprises at least one of a perpendicular distance from a given edge, a length of a

given edge, a horizontal orientation of a given edge, and a vertical orientation of a given edge.

17. A method comprising:

5 introducing a sub-resolution assist feature (SRAF) for an edge of a feature in a photolithographic design;

generating a bridge from the feature to the SRAF, said bridge to define a relationship between the feature and the SRAF; and

providing the feature, the SRAF, and the bridge for a phase assignment, said phase assignment to assign the feature and the SRAF to opposite phases based on the relationship defined by the bridge.

18. The method of claim 17 wherein the SRAF comprises a square SRAF.

19. The method of claim 17 wherein the SRAF comprises a rectangular SRAF, the method further comprising:

resizing the rectangular SRAF into a square SRAF.

20. The method of claim 19 wherein resizing the rectangular SRAF comprises:

20 trimming both ends of the rectangular SRAF an equal amount.

21. A machine readable medium having stored thereon machine executable instructions that when executed implement a method comprising:

determining a spacing for each of a plurality of edges comprising one or more features in a photolithographic design, said plurality of edges having at least a partially predictable layout;

generating a bridge structure for the plurality of edges based on the spacings and the predictable layout, each bridge of the bridge structure to connect one of the plurality of edges to an edge of a neighboring feature; and

providing the features and the bridge structure for a phase assignment, said phase assignment to assign features at opposite ends of each of said bridges to opposite phases.

22. The machine readable medium of claim 21 wherein generating the bridge structure comprises:

categorizing at least one pair of the plurality of edges as near edges; and
filling a space between each pair of near edges with a bridge.

23. The machine readable medium of claim 21 wherein generating the bridge structure comprises:

categorizing at least one pair of the plurality of edges as medium edges;
inserting a sub-resolution assist feature (SRAF) between each pair of medium edges; and
filling a space between each medium edge and its corresponding SRAF with a bridge.

24. The machine readable medium of claim 21 wherein generating the bridge structure comprises:

categorizing a set of the plurality of edges as far edges;

inserting a sub-resolution assist feature (SRAF) for each far edge; and

filling a space extending from one or more of the set of far edges with a bridge.

25. The machine readable medium of claim 24 wherein filling the space comprises:

identifying any of the SRAFs that are within a minimum separation distance from another feature;

increasing a separation distance to at least the minimum separation distance for any identified SRAFs by resizing, merging, and/or deleting the identified SRAFs as needed;

adding a bridge between any far edge and its corresponding SRAF where the corresponding SRAF still exists or was merged; and

adding a bridge between any pair of far edges for which both corresponding SRAFs were deleted.

26. The machine readable medium of claim 21 wherein generating the bridge structure comprises:

introducing a sub-resolution assist feature (SRAF) for one of the plurality of edges having a particular spacing; and

connecting one of the bridges of the bridge structure between the edge having the particular spacing and the SRAF.

27. The machine readable medium of claim 26 wherein generating the bridge structure further comprises:

repeating the introducing and connecting for a plurality of additional edges

5 having the particular spacing.

28. The machine readable medium of claim 26 wherein the particular spacing is a first particular spacing, and wherein generating the bridge structure further comprises:

repeating the introducing and connecting for a plurality of additional edges

10 having a second particular spacing.

29. The machine readable medium of claim 21 wherein generating the bridge structure comprises:

introducing a plurality of sub-resolution assist features (SRAFs), wherein

15 particular ones of the neighboring features comprise the plurality of SRAFs.

30. The machine readable medium of claim 29 wherein providing the features and the bridge structure comprises:

merging the plurality of features and the plurality of SRAFs to a target layer for

20 the phase assignment; and

merging the bridge structure to a bridge layer for the phase assignment.

31. The machine readable medium of claim 21 wherein the photolithographic design comprises a mask design for a contact layer of an integrated circuit design.

32. The machine readable medium of claim 21 wherein the one or more features
5 comprise one of a square feature, an array of square features, a rectangular feature, and an array of rectangular features.

33. The machine readable medium of claim 21 wherein determining the spacing comprises:

measuring each of the spacings as a projection perpendicular from each of the plurality of edges to a neighboring edge or to a maximum projection distance.

34. The machine readable medium of claim 21 wherein the one or more features
15 comprise staggered sets of features having a shorter spacing between neighboring features in neighboring staggered sets than between neighboring features within each set, and wherein generating the bridge structure comprises:

merging each said staggered set into a strip feature; and

filling the bridges between neighboring strip features.

20 35. The machine readable medium of claim 21 wherein the spacing for each of the plurality of edges comprises at least one of a perpendicular distance from a given edge, a length of a given edge, a horizontal orientation of a given edge, and a vertical orientation of a given edge.

36. A machine readable medium having stored thereon machine executable instructions that when executed implement a method comprising:

introducing a sub-resolution assist feature (SRAF) for an edge of a feature in a photolithographic design;

generating a bridge from the feature to the SRAF, said bridge to define a relationship between the feature and the SRAF; and

providing the feature, the SRAF, and the bridge for a phase assignment, said phase assignment to assign the feature and the SRAF to opposite phases based on the relationship defined by the bridge.

37. The machine readable medium of claim 36 wherein the SRAF comprises a square SRAF.

38. The machine readable medium of claim 36 wherein the SRAF comprises a rectangular SRAF, the method further comprising:

resizing the rectangular SRAF into a square SRAF.

39. The machine readable medium of claim 38 wherein resizing the rectangular SRAF comprises:

trimming both ends of the rectangular SRAF an equal amount.

40. An apparatus comprising:

circuitry to determine a spacing for each of a plurality of edges comprising one or more features in a photolithographic design, said plurality of edges having at least a partially predictable layout;

circuitry to generate a bridge structure for the plurality of edges based on the spacings and the predictable layout, each bridge of the bridge structure to connect one of the plurality of edges to an edge of a neighboring feature; and

circuitry to provide the features and the bridge structure for a phase assignment, said phase assignment to assign features at opposite ends of each of said bridges to opposite phases.

41. An apparatus comprising:

circuitry to introduce a sub-resolution assist feature (SRAF) for an edge of a feature in a photolithographic design;

circuitry to generate a bridge from the feature to the SRAF, said bridge to define a relationship between the feature and the SRAF; and

circuitry to provide the feature, the SRAF, and the bridge for a phase assignment, said phase assignment to assign the feature and the SRAF to opposite phases based on the relationship defined by the bridge.